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THERMAL OXIDATIVE STABILITY TEST METHODS FOR JPTS JET FUEL.(U)
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THERMAL OXIDATIVE STABILITY TEST METHODS FOR JPTS JET FUEL

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Fuels Branch

August 1979
Technical Report AFAPL-TR-79-2079
Final Report for Period January 1976 - December 1978

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Various samples of Thermally Stable Jet Fuel (JPTS) produced in accordance with military specification MIL-T-25524, were tested for thermal oxidative stability using the Jet Fuel Thermal Oxidation Tester (JFTOT). Two of the fuel samples had marginal thermal stability and provided data needed for the proposed substitution of the JFTOT for the ASTM-CRC Fuel Coker. Over 130 samples of JPTS fuel, submitted for fuel specification compliance test, were tested for thermal oxidative stability using the JFTOT in lieu of the Fuel Coker. The JFTOT, in conjunction with the Alcor Mark 8A Tube Deposit rater, was found to be suitable for use with JPTS fuels.

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FOREWORD

This report presents the results of test programs involving the thermal oxidative stability of Thermally Stable Jet Fuel (JPTS). Both the Jet Fuel Thermal Oxidation Tester (JFTOT) per American Society of Testing and Materials (ASTM) D 3241 and the ASTM-CRC Fuel Coker per ASTM D 1660 were used. This study was conducted by Royce P. Bradley and Charles R. Martel of the Fuels Branch (SFF), Fuels and Lubrication Division, Air Force Aero Propulsion Laboratory, Wright-Patterson Air Force Base, Ohio. The effort was accomplished under Project Number 3048, "Fuels, Lubrication and Fire Protection," Task 304805, "Aero Propulsion Fuels," and Work Units 30480523, "Parameters Affecting the Thermal Stability and Heat Sink of Hydrocarbon Fuels" and 30480591, "Aero Propulsion Fuels Evaluation and Development." This study covered the time period from January 1976 to August 1978.

This report incorporates work previously reported under AFAPL-SFF-TM-76-27, "JFTOT Tests Using a Marginal JPTS Fuel" dated October 1976 and AFAPL-SFF-TM-76-28, "JFTOT Tests on Thermally Stable Jet Fuel, Batch 81" dated November 1976.

The authors wish to extend their appreciation to Mr. James Purt and Mr. Jerry Harris for running the many JFTOT tests involved in this program. Special recognition is given to Mr. Thomas O'Shaughnessy, Chief of the Aerospace Fuels Laboratory and to Mr. Heanon Gordin, JFTOT operator, for their cooperation and assistance.

This report was submitted by the authors March 1979.

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INTRODUCTION

Military specification MIL-T-25524, Turbine Fuel, Aviation, Thermally Stable, covers a kerosene fuel specifically designed for use in high altitude, subsonic aircraft. A low freezing point and excellent thermal oxidative stability are the primary characteristics that distinguish this thermally stable jet fuel (JPTS) from other kerosene type aviation turbine fuels such as JP-5, JP-8, Jet A, and Jet A-1 fuels.

The American Society of Testing and Materials (ASTM) test method D 1660, Standard Test Method for Thermal Stability of Aviation Turbine Fuels, requires the use of the ASTM-CRC Fuel Coker. The Fuel Coker was developed in the 1950's after fuel lines and nozzles in newly developed aircraft turbine engines plugged with fuel deposits. The Fuel Coker uses a polished aluminum preheater tube to heat the fuel to some predetermined temperature followed by a heated filter assembly used to simulate an engine fuel nozzle. Plugging of the filter assembly, detected by pressure drop measurements across the filter, and the formation of visual deposits on the polished aluminum preheater tube are the criteria used to determine the thermal stability of the test fuel.

Shortcomings of the Fuel Coker resulted in the Coordinating Research Council (CRC) developing a new and improved thermal stability test device. This device is the Jet Fuel Thermal Oxidative Tester (JFTOT). ASTM has developed a new test method using the JFTOT, ASTM D 3241, Test Method for Thermal Oxidation Stability of Aviation Turbine Fuels. The JFTOT was selected as the only approved test method for JP-4, JP-5, and JP-8 aviation turbine fuels as of 1 April 1976.

Thermally stable jet fuel (JPTS) is currently the only military aviation turbine fuel that requires the use of the ASTM-CRC Fuel Coker. The use of the JFTOT with JPTS fuel has been delayed due to a lack of information as to the proper JFTOT test conditions.

This report documents in-house thermal stability experiments with JPTS fuels conducted by the Air Force Aero Propulsion Laboratory Fuels Branch during 1976 thru 1978. Supporting data on JPTS fuel samples submitted for quality control tests were obtained through the cooperation of the San Antonio Air Logistics Center's Aerospace Fuels Laboratory (SFQLA), located at Wright-Patterson Air Force Base, Ohio. SFQLA regularly receives samples of JPTS fuel from the supplier, field storage, and aircraft for analysis. Also, drum storage samples of various batches of JPTS are in storage at Wright-Patterson Air Force Base, Ohio, and are available for test.

This report documents three separate experiments conducted on JPTS fuels. For ease of reading, each experiment is covered in a separate section of the report. Consolidated conclusions and recommendations are presented at the end of the report.

SECTION II

THERMAL OXIDATIVE STABILITY TEST METHOD COMPARISON

1. ASTM-CRC FUEL COKER

The ASTM D 1660 Fuel Coker has an operating pressure of 150 psi (1.03 MPa). Past work indicates the likelihood of some fuels boiling in the preheater section under some test conditions. Specification MIL-T-25524 specifies the use of the Fuel Coker at 450/550/6 for fuels being procured by the Air Force. The first number (i.e., 450) is the preheater section fuel outlet temperature in °F. The second number (i.e., 550) is the filter assembly temperature in °F. The third number (i.e., 6) is the fuel flow rate through the Fuel Coker in lb/hour. The maximum preheater tube metal temperature of the Fuel Coker from Ref 1 is 604°F (318°C).

Deposits formed on the Fuel Coker preheater tube are rated by comparing the deposits to standard color codes with Codes of 0, 1, and 2 being passing and Codes of 3 or greater constituting a failure. Pressure differential that forms across the test filter during the test is measured on a mercury manometer, and an increase in the differential pressure of 3 in. Hg or greater constitutes a test failure.

2. JET FUEL THERMAL OXIDATIVE TESTER (JFTOT)

The ASTM D 3241 JFTOT apparatus is similar in concept to the Fuel Coker. Major differences are in the substantially lower fuel flow (3 ml/min vs. 6 lb/hr (60 ml/min) for the Coker), shorter test time (2 1/2 hours vs. 5 hours for

the Coker), higher operating pressure (3.43 MPa vs. 1.03 MPa), and improved test precision. In the JFTOT the test severity is controlled by the maximum metal temperature of the heater tube. Thus, a 260°C (500°F) JFTOT test condition means that the heater tube surface temperature will be 260°C at its hottest point. The test filter housing temperature is not independently controlled but is heated by the effluent fuel from the heater tube assembly.

JFTOT heater tube deposits were rated two ways. The Visual Rating of the JFTOT heater tube deposits is essentially the same method used with the Fuel Coker, but the Appendix B procedure of MIL-T-5624K was used which states that deposits that are abnormal in color or of the peacock (rainbow) type constitute test failures. The Alcor Mark 8A Tube Deposit Rater (TDR) was also used to rate JFTOT heater tube deposits. An X-Y plotter was connected to the TDR such that the tube surface SPUN TDR rating was plotted against the tube position for each tube, both before and after each JFTOT test. The maximum difference between the post-test and pretest TDR rating was reported as the maximum Delta SPUN TDR rating.

A SPUN TDR rating of 18 has been reported to be approximately equivalent to a Code 3 Visual rating (Ref. 2). However, subsequent work conducted at the Aero Propulsion Lab indicates that a maximum TDR rating of 12 is preferable to insure that all peacock type deposits exceed (i.e., fail) the maximum allowable TDR limit (Ref. 3).

3. BREAKPOINT TEMPERATURE

As previously discussed, a Visual Rating of less than Code 3 is normally considered a pass and a Code 3 or greater a fail. However, when several tests are conducted over a spectrum of temperatures the concept of breakpoint temperatures is usually introduced. In this report, breakpoint temperatures are obtained by plotting the ratings versus temperatures and hand fitting a line through the data.

The temperature at which the line passes through the selected rating level (e.g., Code 3) is taken to be the breakpoint temperature.

The approach just described for obtaining the breakpoint temperature is considered to be significantly better than other methods used. For example, the breakpoint temperature is sometimes taken to be the highest temperature at which a test was conducted without obtaining a rating equal to or greater than the selected rating level. This approach can be affected significantly by the incremental spacing of the test temperatures.

SECTION III

JFTOT TESTS USING A MARGINAL QUALITY JPTS FUEL

1. BACKGROUND

When a MIL-T-25524 JPTS fuel (identified as Batch 32) became thermally unstable during extended storage, a series of JFTOT tests were conducted on the fuel by AFAPL/SFF to obtain a correlation between the ASTM-CRC Fuel Coker and the Jet Fuel Thermal Oxidative Tester.

The thermal stability history for the Batch 32 JPTS fuel is given in Table 1. The Fuel Coker results are for test conditions of 400/500/6.

Table 1 - Thermal Stability Measurement Data for Batch 32

	Standard Coker Results	
Date	Visual Code	Pressure Drop (in. Hg)
01/17/73	1	0.0
03/13/73	1	0.0
04/05/73	1	0.0
05/29/73	1	0.0
06/29/73	1	0.0
09/03/73	1	0.0
12/03/73	2	0.0
01/08/74	3	0.0
01/24/74	1	0.0
02/28/74	1	0.0
04/23/74	1	0.0
05/07/74	1	0.0
06/03/74	1	0.0
06/06/74	1	0.0
08/28/74	3	0.0
09/20/74	3	0.0
10/03/74	3	0.0

The fuel was produced during the fall of 1970. Examination of the data shown in Table 1 reveals that the thermal stability of the fuel decreased to a level of 50°F below the specification limit by the fall of 1974.

2. TEST RESULTS AND DISCUSSION

The results of the JFTOT tests run on Batch 32 fuel are documented in Table 2. All JFTOT tests were run in accordance with ASTM D 3241 [150 minute test at a test pressure of 3.43 MPa (500 psig)], except for Test Numbers 2699 and 2694 which were run at test pressures near and below the bubble point of the fuel, respectively. The deposits were dull in appearance on all of the tubes. The deposits on Tubes 2207, 2215, 2218, 2227, 2230, and 2694 were blotchy.

The data from Table 2 are plotted in Figures 1 and 2. The diamond shaped points are for data generated using JFTOT Serial Number 002 and the circles are for data generated using JFTOT Serial Number 008. There appears to be no bias between the two JFTOT's.

In Figure 1 the SPUN TDR ratings are plotted against the test temperature. The TDR ratings show a rapid rise starting at about 290°C (554°F) and reach a plateau extending from about 315°C to 390°C (599°F to 734°F). Above 390°C the SPUN TDR ratings drop rapidly. Hazlett (Ref. 4) and Szetela (Ref. 5) have observed fuel deposit formation characteristics similar to that seen in Figure 1. They found that as the test temperature increases the rate of deposition increases, then decreases, and then again increases. Szetela found that for an air-saturated JP-5 fuel the deposit formation rate reaches a maximum at about 400°C (752°F), drops sharply to a minimum at a temperature of about 427°C (800°F), and then rises as the temperature is further increased. The SPUN TDR ratings in Figure 1 appear to be following the same general trend. It is interesting that the sharp drop in deposits occurs at about the critical temperature of the fuel; i.e., about 390°C (734°F). The effect of super critical operation on deposit formation is not understood, however.

TABLE 2 - JFTOT TEST RESULTS FOR JPTS BATCH 32

Test No.	Test Temp °C	Test Pres. MPa	Visual Rating	SPUN TDR	Delta SPUN TDR	Delta Pres. (mm Hg)
2207	395	3.43	<3A	22.	20.5	2
2215	390	3.43	<3A	27.	26.	0
2218	380	3.43	<2A	13.	12.	0
2227	395	3.43	1A	4.	6.	0
2230	395	3.43	1	6.5	7.	0
2248	390	3.43	<3A	26.	27.5	0
2313	315	3.43	<2A	22.	23.	0
2323	330	3.43	<3A	21.	23.	0
2327	345	3.43	<3A	24.9	27.5	0
2331	360	3.43	<3A	26.	28.	0
2368	300	3.43	1A	1.	4.	0
2542	290	3.43	<2A	8.	10.	3
2547	310	3.43	<2A	13.5	17.	0
2588	300	3.43	1A	14.9	14.5	0
2596	300	3.43	<2A	17.	16.	0
2598	310	3.43	<3A	18.	20.	0
2600	295	3.43	1A	7.5	11.5	0
2605	320	3.43	1	14.	16.	0
2607	315	3.43	2	27.	30.	0
2615	330	3.43	4	34.	35.	0
2627	340	3.43	<3 A	24.	25.	0
2631	330	3.43	<4 A	22.	25.	0
2635	320	3.43	<3	30.	30.	0
2694	318	0.76	>4A	26.5	26.5	1
2699	318	1.03	2A	25.5	25.5	0

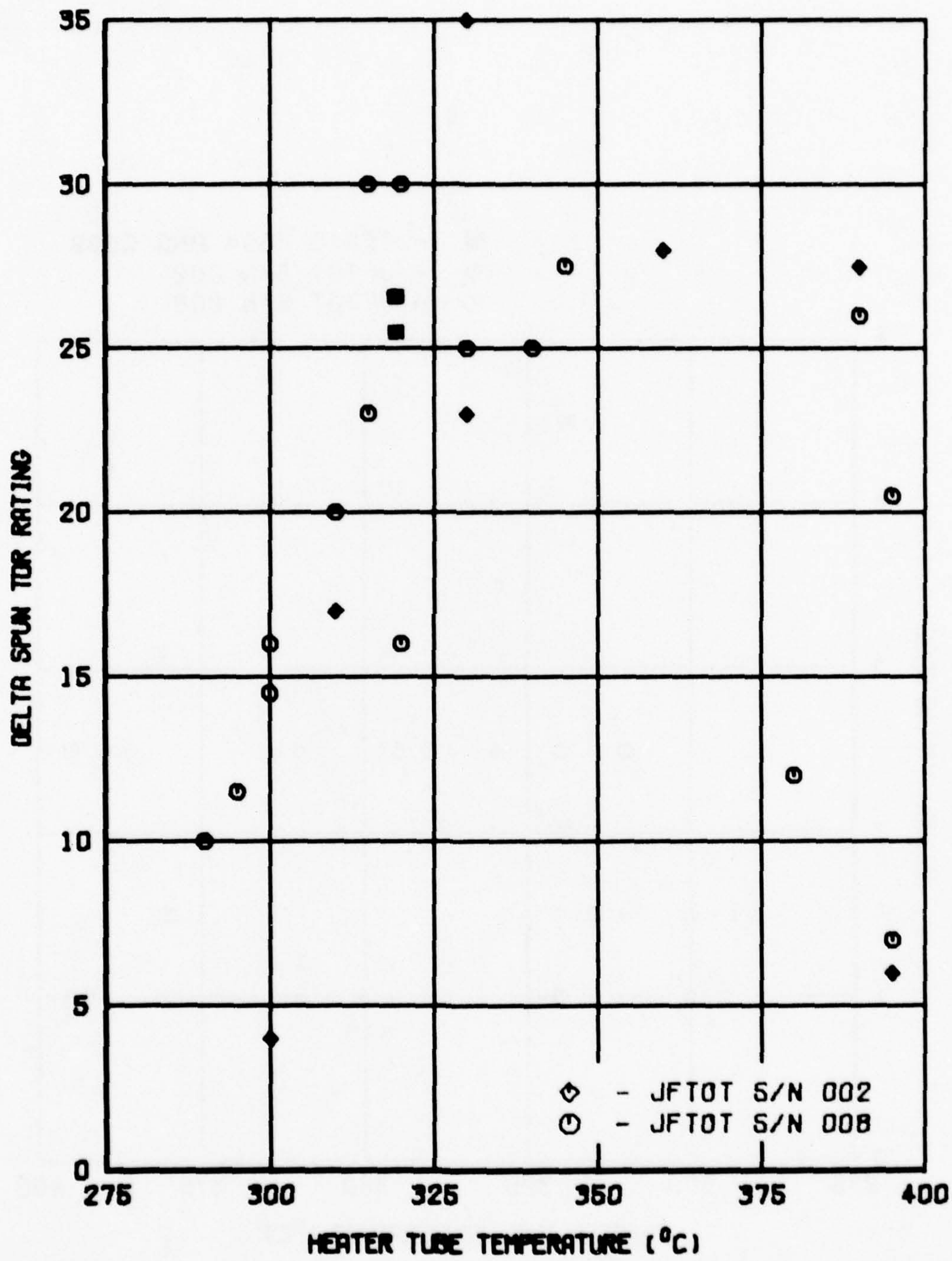

FIGURE 1. DELTA SPUN TDR RATINGS FOR BATCH 32

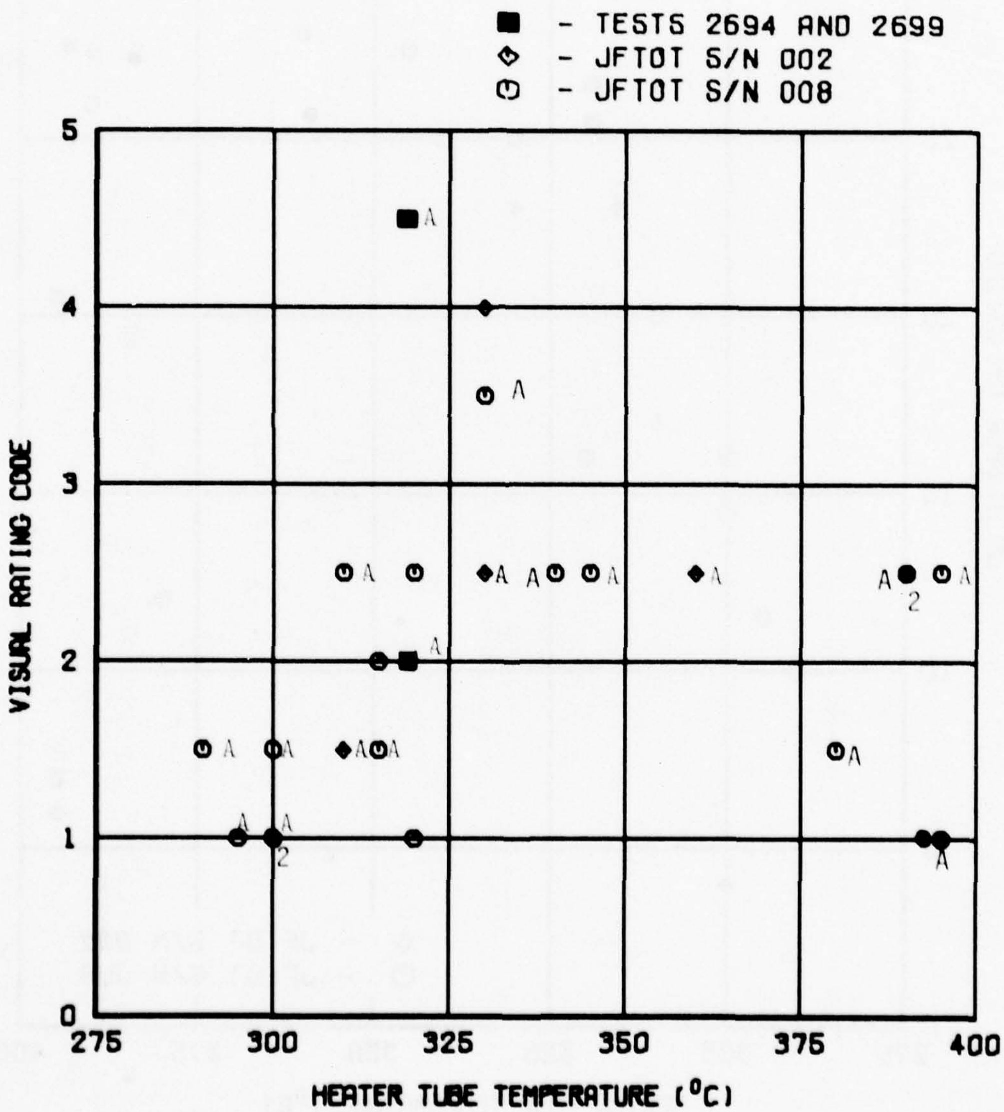

FIGURE 2. VISUAL RATINGS FOR BATCH 32

In Figure 2 the Visual Ratings are plotted against the test temperature and show a similar pattern to Figure 1, but with a sharp peak at a test temperature of 330°C (626°F). Only at 330°C was a Code 3 reached or exceeded. On either side of 330°C the highest Visual Ratings obtained were only a Code <3 (i.e., between a Code 2 and a Code 3). Thus, for Batch 32 JPTS fuel, a Code 3 breakpoint can only be found at 330°C. However, if abnormal deposits are considered, the breakpoint temperature is less than 290°C.

In Figures 1 and 2 the two solid square data points are for Test Numbers 2694 and 2699, both obtained at a test pressure well below the 3.43 MPa (500 psig) specified. For Batch 32 JPTS fuel, the bubble point is about 1.03 MPa (150 psig) at a temperature of 318°C (604°F). In Figure 1 the top solid square is for test number 2694 at a test pressure of 0.76 MPa (110 psig) which is well below the bubble point, and the bottom square is for test number 2699 at a test pressure of 1.03 MPa (150 psig). For both tests it appears that the reduced test pressure did not significantly affect the SPUN TDR ratings. In Figure 2, however, the Visual Rating for test number 2694 was significantly higher than for the tests at the higher pressure.

A Visual Rating Code 2 temperature was obtained at about 310° to 315°C (590° to 599°F). This is still higher than a SPUN TDR rating of 12 breakpoint temperature (about 295°C) and roughly comparable to a SPUN TDR rating of 18 breakpoint temperature (about 310°C). Thus, whether the maximum allowable TDR SPUN limit is 12 or 18, the breakpoint temperature would be equal to or less than that for a Visual Rating limit of Code 2. This observation agrees with previous results, i.e., the TDR is more sensitive to deposits than is the Visual Rating method at high breakpoint temperatures for JP-7 and JPTS Fuels

(References 6 and 7). The purpose for discussing a SPUN TDR rating of 18 for this fuel will become obvious later in this report when the results are compared to results previously obtained.

As the Batch 32 JPTS fuel had previously failed the Fuel Coker at test conditions of 400/500/6, a comparison can be made between the JFTOT breakpoint conditions and the Fuel Coker at the 400/500/6 test condition. For a SPUN TDR limit of 12, the JFTOT breakpoint temperature is about 295°C (563°F). The maximum preheater tube metal temperature for the Fuel Coker at the 400/500/6 test condition is 283°C (542°F). This agreement is much better than is obtained at lower breakpoint temperatures.

For a SPUN TDR limit of 18, the equivalent JFTOT test temperature is 310°C (590°F). This is a difference of 27°C (49°F) between the maximum metal temperature of the JFTOT heater tube and the Fuel Coker preheater tube. One major difference between the two test devices is that the JFTOT test is only 2 1/2 hours in length as compared to the 5 hour long Fuel Coker test. This undoubtedly accounts for part of the difference in test temperature. Test pressure (3.43 MPa vs. 1.03 MPa) may also be a contributing factor.

Figure 3 is a reproduction of Figure 12 from Reference 8 in which a correlation was made between the JFTOT using a SPUN TDR rating level of 18 and the Fuel Coker. Added to the figure are the equivalent breakpoints for JPTS Batch 32 at a SPUN TDR limit of 12 and 18. The Batch 32 SPUN 18 datum point falls between the Y on X and the X on Y correlation curves previously obtained. The Y on X regression line assumes that all of the error is in the JFTOT breakpoint temperatures whereas the X on Y assumes that all of the error is in the Fuel Coker. This additional datum point should slightly improve

	Y ON X	X ON Y
SLOPE =	0.788	1.65
CORR COEF =	0.69	0.69
STD ERR =	23.2	20.3
NR OF PTS =	36	36
300 F INTCP =	492	438

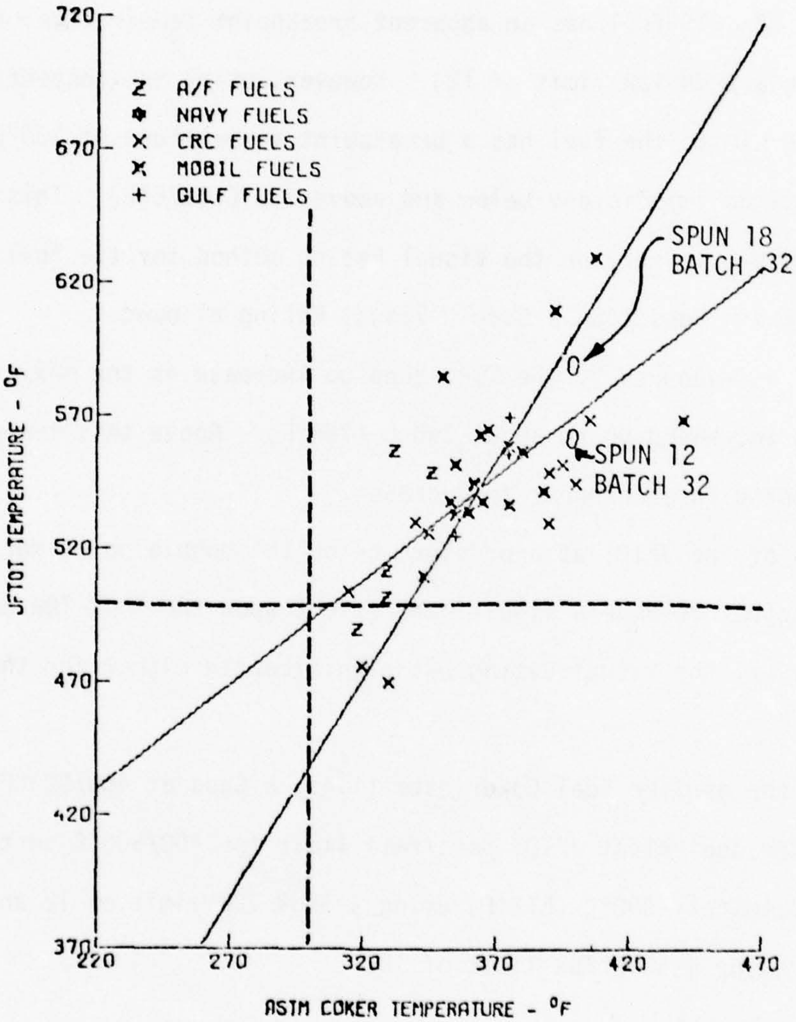

FIGURE 3. SPUN 18 TUBE DEPOSIT RATING CORRELATION RESULTS

the correlation over that listed on Figure 3. The Batch 32 SPUN 12 datum point is below Y on X correlation curve and indicates that there is a significant breakpoint temperature difference between a SPUN 12 and a SPUN 18 TDR limit.

3. SUMMARY

The Batch 32 JPTS fuel has an apparent breakpoint temperature of about 295°C (based on a SPUN TDR limit of 12). However, using the conventional Code 3 Visual Rating Limit, the fuel has a breakpoint temperature of 330°C with less than Code 3 ratings immediately below and above 330°C (626°F). This behavior makes it impossible to rely on the Visual Rating method for the fuel using a pass/fail limit of "less than a Code 3 Visual Rating allowed."

Deposits, as measured by the TDR, tend to increase as the maximum metal temperature is increased up to about 390°C (734°F). Above this temperature the amount of deposits formed appear to decrease.

Operation of the JFTOT at a pressure below the bubble point for Batch 32 fuel did not appear to have a significant effect upon the SPUN TDR deposit ratings. However, the Visual Rating was significantly higher for this test condition.

Based on the earlier Fuel Coker data (i.e., a Code at 400/500°F operating conditions), the equivalent JFTOT pass/fail limit for 400/500°C on the Fuel Coker is approximately 300°C (572°F) using a SPUN TDR limit of 12 and about 310°C (590°F) using a SPUN TDR limit of 18.

SECTION IV

JFTOT TESTS ON JPTS FUEL, BATCH 81

1. BACKGROUND

Batch 81 Thermally Stable Jet Fuel (JPTS) was produced to specification MIL-T-25524B, Turbine Fuel, Aviation, Thermally Stable, and delivered to the Air Force in January 1975. A complete fuel specification test report for JPTS Batch 81 fuel is included as Table 3. A drum of the fuel was shipped to the AF Aero Propulsion Laboratory and placed in ambient storage at that time. Early in 1976 a 10 gallon sample of the fuel was placed in cold storage at about 4°C (39°F). JFTOT tests were conducted on the fuel from February 1976 until late October 1976. These JFTOT tests were conducted at various test temperatures and pressures.

2. TEST PROCEDURES AND TEST CONDITIONS

Two Jet Fuel Thermal Oxidation Testers, Serial Numbers 002 and 008, were used for the tests reported herein. The test procedure was in accordance with ASTM D 3241, except that for some of the tests at test temperatures of 283°C (541°F) and 318°C (604°F) the JFTOT operating pressure was varied over the range of 0.69 MPa (100 psig) to 3.43 MPa (500 psig). The series of tests at constant pressure was conducted over a temperature range of 315°C to 385°C (599°F to 725°F). The 283°C test temperature is the maximum metal temperature of the Fuel Coker preheater tube when operated at a 400/500/6 test condition. Many tests were conducted at 318°C (604°F) which is the maximun metal temperature of the Fuel Coker preheater tube when operated at the 450/550/6 test condition required by the fuel specification.

TABLE 3

SPECIFICATION TEST RESULTS FOR JPTS BATCH 81, JAN 1975

Test Requirement	Spec Limits	Test Results	Test Method
Color, Saybolt	None	+30	D 156
Aromatics, volume %	5 to 20	10.5	D 1319
Olefins, volume %	3 Max.	0.5	D 1319
Mercaptan Sulfur, weight %	0.001 Max.	0.00004	D 1219
Sulfur, Total, weight %	0.3 Max.	0.0001	D 1266
Distillation, temperature, °C (°F)			D 86
Initial Boiling Point	157 (315) Min.	177 (350)	
10% Recovered	193 (380) Max.	183 (362)	
50% Recovered	204 (400) Max.	186 (367)	
90% Recovered	232 (450) Max.	194 (381)	
Final Boiling Point	260 (500) Max.	210 (409)	
Flash Point, °C (°F)	43 (110) Min.	59 (138)	D 93
Density, kg/m^3 (sp. gravity)	766.9 to 797.2	777.9 (0.7779)	
Gravity, °API at 60°F	46.0 to 53.0	50.4	D 287
Freezing Point, °C (°F), Max.	-53.3 (-64)	-63 (-81)	D 2386
Viscosity, at -40°C, mm^2/s (cSt)	12.0 (12.0)	6.9 (6.9)	D 445
Heating Value, cal/gm (Btu/lb)	10,222 (18,400) Min.	10,407 (18,750)	
Aniline X Gravity (°F X °API)	5,250 Min.	7711	D 611 & D 287
Smoke Point, mm	25.0 Min.	30	D 1322
Hydrogen Content, weight %	None	14.39	D 3343
Copper Strip Corrosion, 2 hrs at 100°C	No. 1 Max.	1a	D 130
Thermal Stability, at 450/550/6			D 1660
Visual Rating	<3	1	
Filter pressure drop, in Hg	3.0 Max	0.2	
Water Separometer Index, Modified	Report	70	D 2550
Existent Gum, mg/100 ml	5.0 Max.	0.2	D 381
Potential Gum, mg/100 ml	10.0 Max.	0.2	D 873
ADDITIVES:			
DMD Inhibitor	Optional	1.75 lb/1000 bbl	
JFA-5	3 to 4 lb/1000 bbl	3.5 lb/1000 bbl	
PPX-441 Antioxidant	Optional	6.5 lb/1000 bbl	
Fuel System Icing Inhibitor	0.10 to 0.15 Vol %	0.131 vol %	

The bubble point for a similar JPTS fuel has been calculated using ASTM D 2889. The approximate bubble point of the fuel at 283°C (541°F) is 0.79 MPa (115 psig), and at 318°C (604°F) the approximate bubble point is 1.03 MPa (150 psig). This indicates that when JPTS fuel is in the Fuel Coker at the specified 450/550/6 test condition [maximum preheater metal temperature of 318°C (604°F) and an operating pressure of 1.03 MPa (150 psig)], the fuel may boil in the preheater tube test section. To determine the effects of two-phase flow (i.e., boiling) on the JFTOT test results, the JFTOT operating pressure was varied below and above 1.03 MPa (150 psig) while holding the test temperature constant at 318°C (604°F).

3. TEST RESULTS AND DISCUSSION

a. Test Temperature as Variable

The JFTOT test data obtained with JPTS Batch 81 fuel using the JFTOT by ASTM Method D 3241 are summarized in Table 4. The JFTOT heater tube temperature was varied to determine tube deposit formation. Tests 2703 and 2707 in Table 4 included the use of an unstirred heated reservoir for the test fuel. The reservoir was preheated to 150°C (302°F) prior to starting the fuel flow through the JFTOT. This preheating required 15 to 20 minutes and was based on the temperature of the metal in contact with the fuel (Reference 9).

Plots of the tube deposit ratings versus the JFTOT heater tube test temperature are shown in Figures 4 and 5. No definite trend in Visual Ratings versus the heater tube temperature can be ascertained. For the two heated reservoir tests, however, the tube deposits were darker than for the unheated reservoir tests.

A plot of the ALCOR Mark 8A Tube Deposit Rater (TDR) data (i.e., the delta SPUN TDR ratings) versus the heater tube test temperature is shown in Figure 5.

TABLE 4

JPTS BATCH 81 JFTOT TEST DATA

Test Nr.	JFTOT S/N	TEST Temp. (°C)	TEST Pres. (MPa)	TUBE DEPOSIT RATINGS Visual	SPUN TDR	Delta SPUN TDR	Delta P (mm Hg)	Heated Reservoir at 302°F
2668	008	345	3.43	1	4.	4.	0	N/A
2674	008	330	3.43	<2	1.5	3.	0	N/A
2692	008	385	3.43	<2	8.	8.	0	N/A
2695	008	315	3.43	1	1.5	2.5	0	N/A
2697	008	360	3.43	1	6.	5.0	0	N/A
2703	002	360	3.43	2	16.	14.	0	Yes
2707	002	330	3.43	<2	10.	8.	0	Yes

NOTE: All tests are 150 minute tests that were run during February and March 1976.

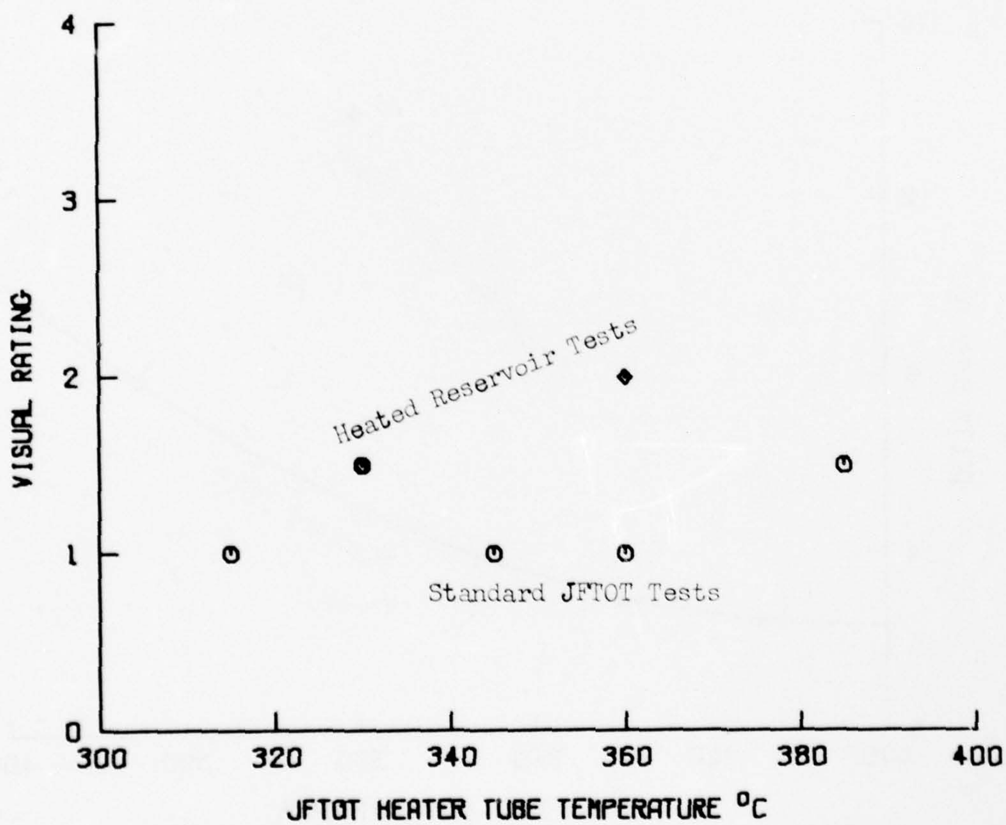

FIGURE 4. VISUAL RATINGS FOR BATCH 81

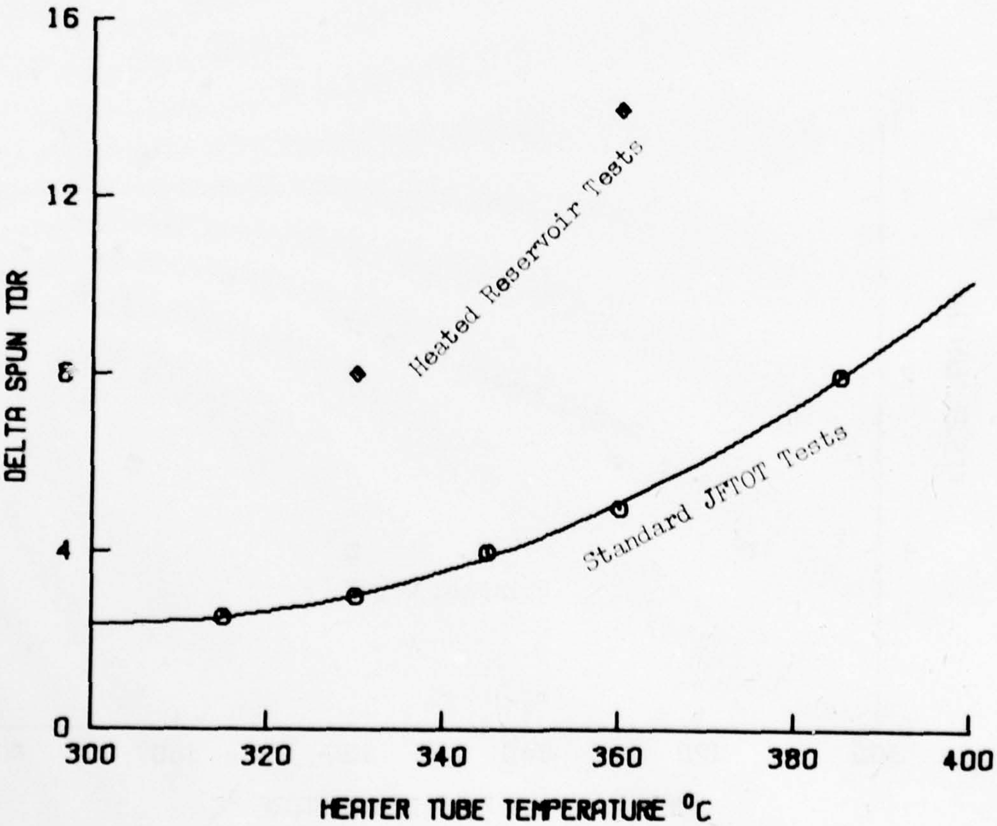

FIGURE 5. TDR RATINGS FOR BATCH 81

The five data points for the unheated reservoir tests form a good curve. The two heated reservoir data points have significantly higher TDR ratings. Figure 5 indicates that the use of the heated reservoir does significantly increase the severity of the JFTOT test. Comparing Figures 4 and 5, it is obvious that the TDR ratings are much more informative than the Visual Ratings for this fuel. This improvement in information is primarily due to the greater resolution of the TDR that results from the larger number of scale divisions.

b. Test Pressure as Variable

The results of the various JFTOT tests conducted on JPTS fuel Batch 81 with the test pressure as the primary variable are documented in Table 5. All tests were conducted at a test temperature of 318°C (604°F) except for test numbers 2721, 2722, and 2726 which were conducted at a test temperature of 283°C (541°F). Figure 6 is a plot of the Visual Ratings of the heater tube deposits for all tests conducted at 318°C (604°F). Note that none of the tube deposits rated a Code 3 or greater although several of the heater tubes did have abnormal deposits (i.e., blue or gray in color). Several tests conducted at the lower test pressures gave abnormal deposit failures, but as the test pressure increased, the number of tests giving abnormal deposits tended to decrease. At the standard test pressure of 3.43 MPa, none of the four tests failed due to abnormal deposits.

Figure 7 is a plot of the TDR ratings plotted against the JFTOT tests pressure. Although there is a great deal of data scatter, especially at the lower test pressures, there is a trend toward lower tube deposit TDR ratings as the test pressure is increased. The data scatter appears to be especially severe at test pressures below the estimated fuel bubble point, i.e., about 1.03 MPa (150 psig).

TABLE 5

JFTOT TEST DATA FOR JPTS BATCH 81 WITH TEST PRESSURE AS VARIABLE

Test Nr.	JFTOT S/N	Test Temp (°C)	Pres. (MPa)	Visual Code	SPUN TDR	Delta SPUN TDR	Delta P (mm Hg)	Date of Test (Mo/Yr)
2704	008	318	0.83	2A	17.	19.	0	3/76
2708	008	318	1.38	1	3.	3.5	0	3/76
2716	008	318	1.03	1+	3.3	5.	0	3/76
2718	002	318	0.96	2	5.5	6.	1	4/76
2720	008	318	0.86	2A	5.	7.	0	4/76
2721	008	283	0.69	1	1.	2.	0	4/76
2722	002	283	0.55	1	2.6	3.	0	4/76
2726	008	283	0.41	1	0.	3.	3	4/76
2818	008	318	1.21	1	5.	6.5	0	8/76
2819	002	318	1.03	1	7.	7.	0	8/76
2820	008	318	2.41	1	8.	5.	0	8/76
2821	002	318	1.72	1+	12.	12.	0	8/76
2822	002	318	3.43	1	4.	6.	0	8/76
2828	002	318	3.43	1	6.	6.5	0	8/76
2829	008	318	3.43	1	8.	7.	0	8/76
2830	002	318	3.43	1	5.	6.5	0	8/76
2831	008	318	1.72	1	6.5	10.	0	8/76
2846	002	318	1.38	2	15.5	16.5	0	9/76
2847	008	318	1.38	2	7.	8.	0	9/76
2848	002	318	1.72	2+A	12.5	16.5	0	9/76
2849	008	318	2.41	2+A	5.	6.5	0	9/76
2874	002	318	1.03	1+A	6.5	10.	0	9/76
2875	008	318	0.83	2	24.	25.5	0	9/76
2882	008	318	0.83	1+A	14.	15.	0	9/76
2887	002	318	0.83	2	8.	12.	0	9/76
2905	002	318	1.21	2	14.5	13.	0	10/76
2906	008	318	1.21	2A	11.	10.	0	10/76

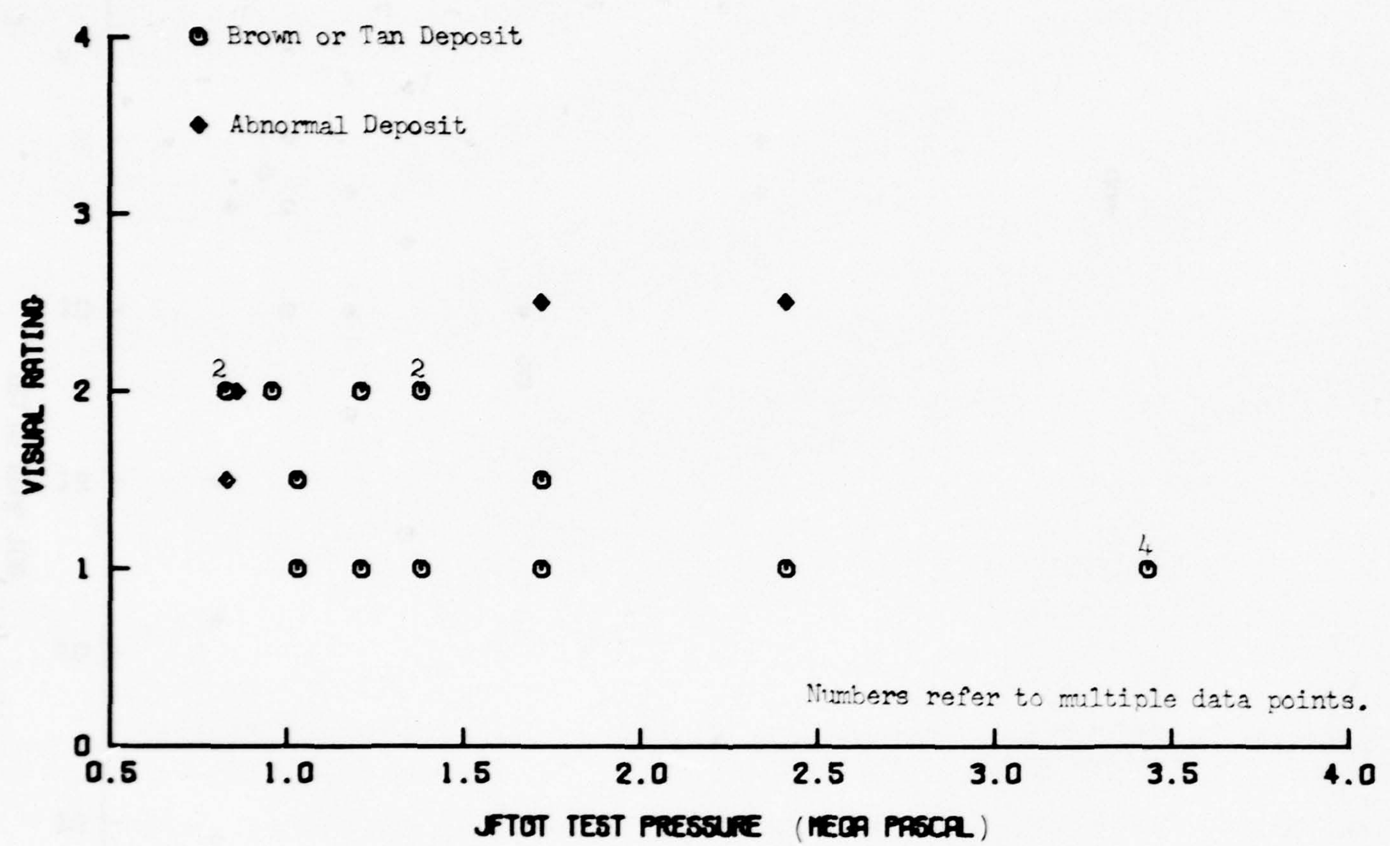

FIGURE 6. EFFECT OF TEST PRESSURE ON VISUAL RATINGS FOR BATCH 81 AT 318 °C

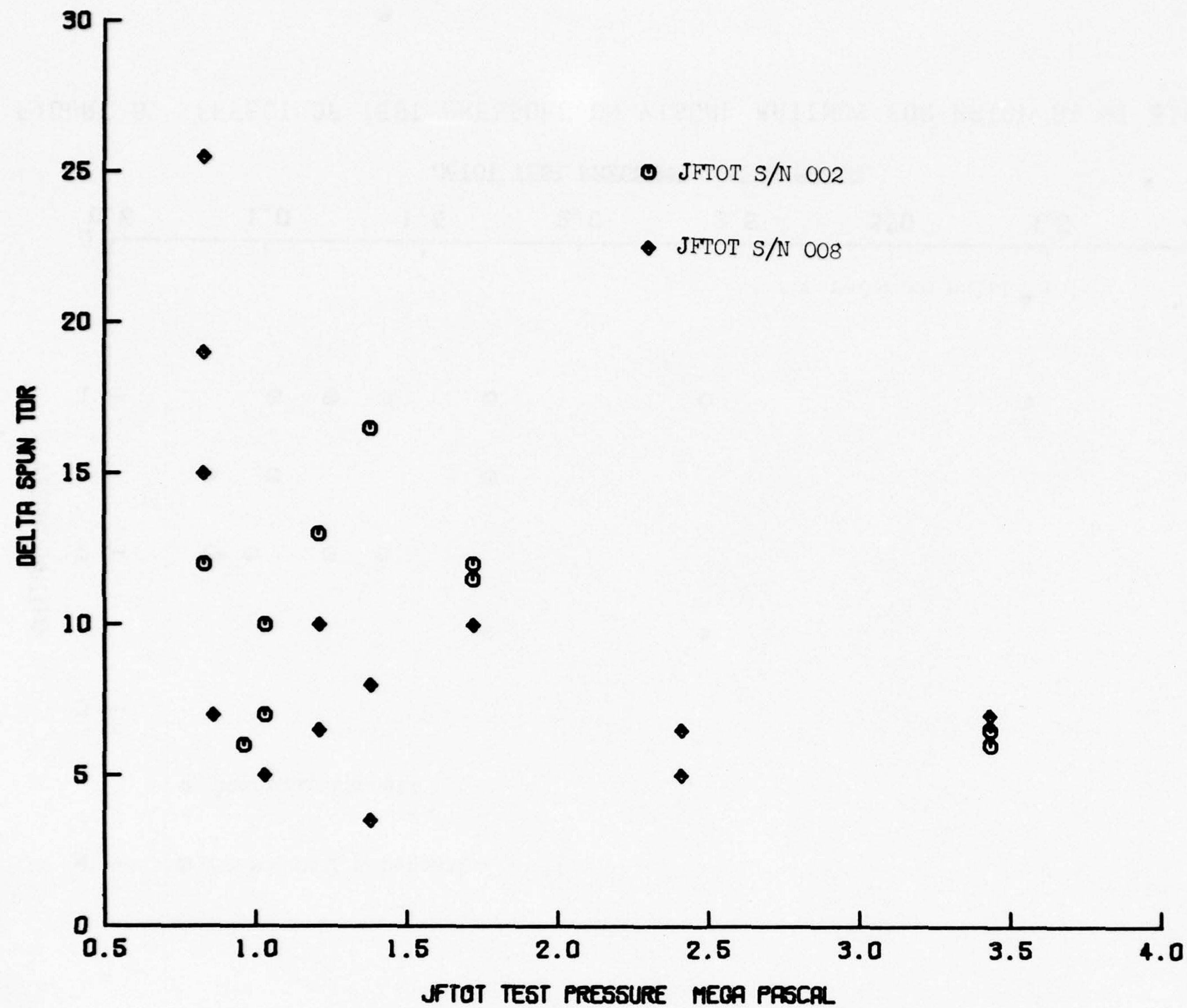

FIGURE 7. EFFECT OF TEST PRESSURE ON DELTA SPUN TDR RATINGS FOR BATCH 81 AT 318 °C

During the seven months that the data were being obtained, it appeared that the TDR ratings for repeat tests became slightly higher as time passed. Consequently, a plot was made of tests run at the same test conditions but separated in time by a period of 2 months or greater. This plot is shown in Figure 8. Note that for 3 of the 4 cases, a very definite increase in TDR ratings was obtained. Figure 8 includes the rate of TDR increase per month for the four sets of data. The average of these four rates is about 1.24 TDR units per month increase, but this may be slightly high due to the one set of data at 1.21 MPa that was only for a period of 2 months. If we arbitrarily select a rate increase of 1 TDR unit per month due to fuel aging, then the TDR data points of Table 5 can be corrected for the effects of fuel aging. Figure 9 is a plot of the Delta SPUN TDR data corrected for fuel aging as plotted against the JFTOT test pressure. A marked reduction in data scatter is seen when Figure 9 is compared to Figure 7. This indicated that the fuel was changing in thermal stability during the seven months that the test data were being obtained. Also, note that the four corrected tests points of Figure 9 at 3.43 MPa agree relatively well with the earlier test data plotted in Figure 5 at 318°C (604°F).

Figure 9, with the reduced data scatter, indicates that the JFTOT test pressure is a major variable. The present ASTM D 3241 test pressure specified is 3.43 MPa (500 psig). This appears to be a good choice from the standpoint of minimum data scatter, but may require a higher test temperature than would be required for a lower test pressure.

The reasons for test pressure affecting the test severity are not understood. At test pressures at or below the bubble point of the fuel, the two-phase fuel flow can be cited, although exactly how two-phase flow affects the

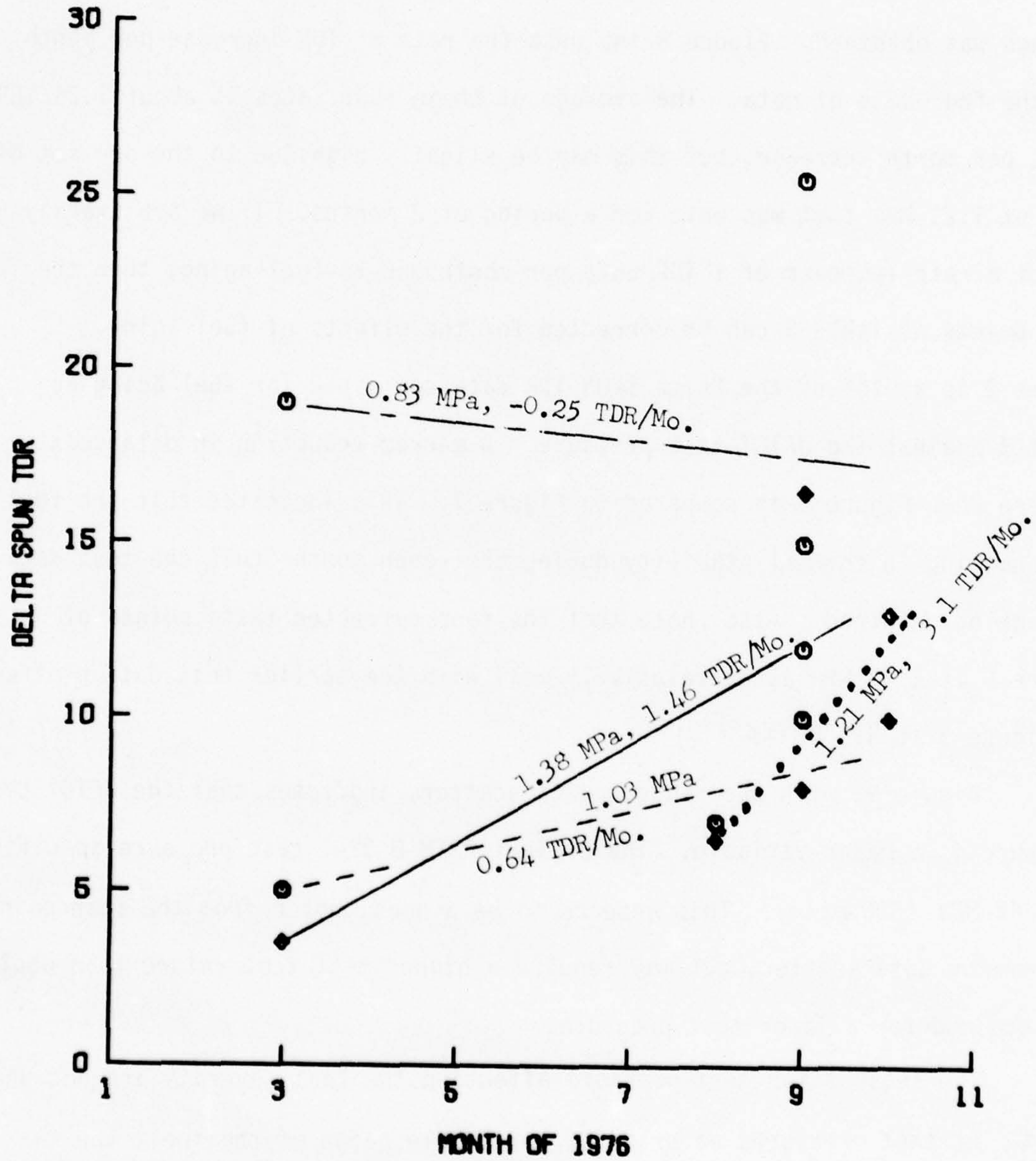

FIGURE 8. EFFECT OF FUEL AGING ON JFTOT RESULTS FOR BATCH 81

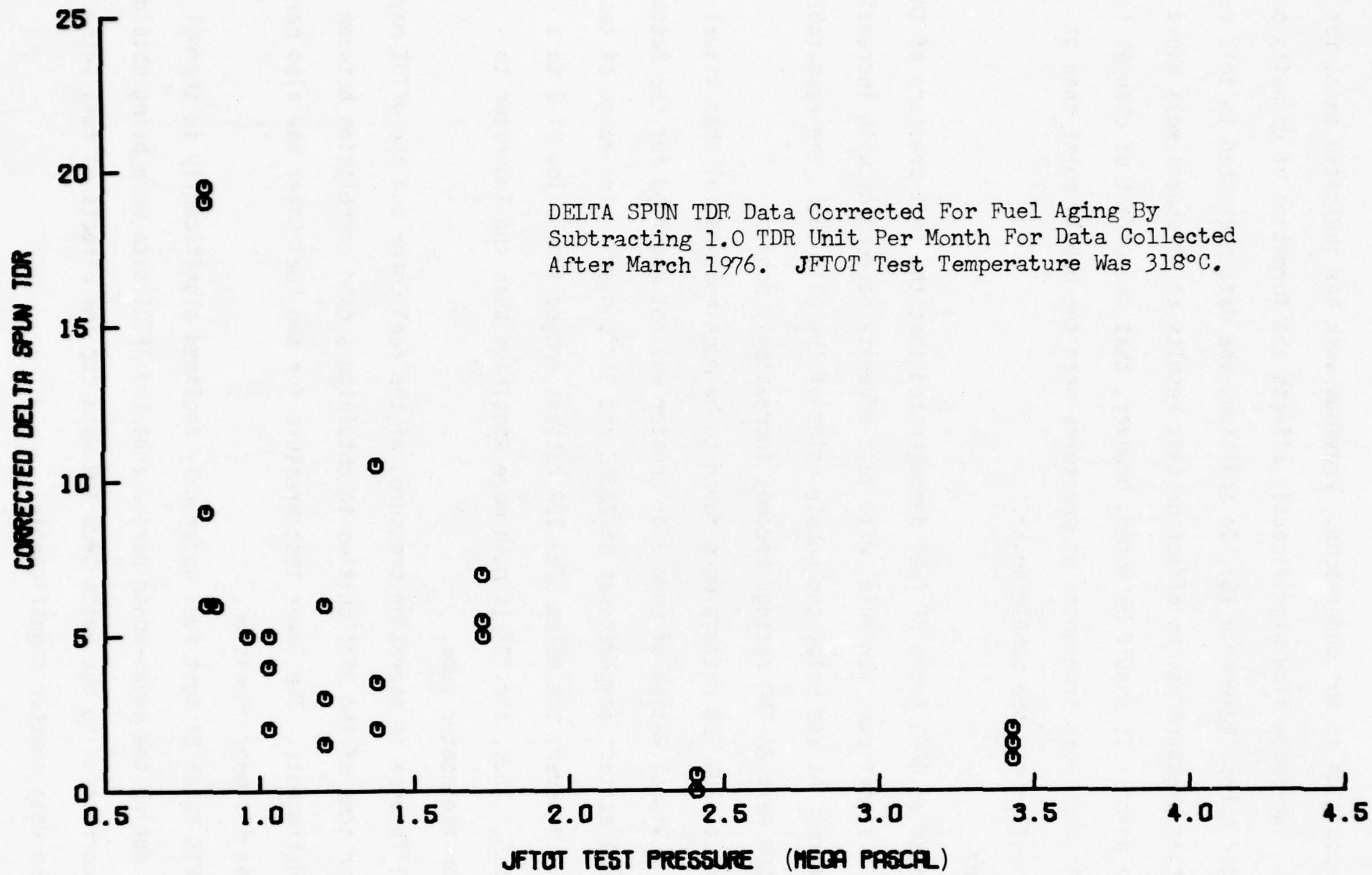

FIGURE 9. EFFECT OF TEST PRESSURE ON DELTA SPUN TDR RATINGS FOR BATCH 81 AT 318 °C CORRECTED FOR AGING

rate of deposition is not understood. Previous work has indicated that, for some fuels, two-phase flow significantly affects the formation of deposits on JFTOT heater tubes (Reference 10). In addition, the data presented in this report indicate that pressure has an effect on test results at pressures well above the bubble point. It should be noted, however, that the effect of changes in pressure is much more pronounced at pressures near the bubble point than at pressures well above the bubble point.

4. SUMMARY

The tests on JPTS Batch 81 fuel demonstrated that the test pressure of the JFTOT was a significant variable, with test severity decreasing with increasing test pressure. At and below the bubble point of the JPTS fuel, the repeatability of the ALCOR Mark 8A TDR ratings becomes increasingly poor.

The Delta SPUN TDR ratings were found to be much more useful than Visual Ratings. A Visual Rating of Code 3 or greater was not recorded for the Batch 81 JPTS fuel at test temperatures of 283°C and 318°C over a wide range of test pressures. However, the delta SPUN TDR ratings ranged from a low of 2 to a high of 25.5. Thus, the TDR is much more sensitive than the Tuberator to deposits on the heater tube.

The difference in operating pressures of the Fuel Coker and the JFTOT may account for some of the difficulties in obtaining a good correlation between the two instruments. The lower test pressure for the Fuel Coker may also partially account for its poor precision.

The JPTS Batch 81 test fuel apparently declined significantly in thermal stability during the seven-month period that the JFTOT data were being obtained. A simple correction to the Delta SPUN TDR data for the effects of fuel aging reduced the data scatter significantly.

SECTION V

THE JFTOT AS A QUALITY CONTROL TEST FOR JPTS FUEL

1. BACKGROUND

The Air Force Aerospace Fuels Laboratory (SFQLA) located at Wright-Patterson AFB, Ohio, regularly receives samples of JPTS fuels for quality control tests. As of the end of 1978, SFQLA has tested over 130 samples of JPTS fuels using the JFTOT. The JFTOT tests were conducted at a tube temperature of 335°C (635°F) for 2.5 hours at a pressure of 3.43 MPa. These conditions were selected with the expectation that they would produce the same test conclusions as produced by the Fuel Coker at 450/550°F.

2. TEST RESULTS AND DISCUSSION

The results obtained by SFQLA using the JFTOT at a test temperature of 335°C (635°F) are presented in Table 6. Only four of these JPTS fuel samples failed the JFTOT; Sample Numbers 76-F-2572, 77-F-813, 78-F-1068 and 78-F-1297. All of these samples were from Batch 79 stored in drums at Eielson AFB, Alaska. Sample Number 76-F-2572 was received 3 December 1976, Sample Number 77-F-813 was received 3 May 1977, Sample Number 78-F-1068 was received 10 May 1978, and Sample Number 78-F-1297 was received 6 Jun 78. A summation of the fuel inspection reports for the first of these two samples and also for the Batch 79 fuel when produced is presented in Table 7.

Subsequent to the failure of fuel samples 76-F-2572 and 77-F-813 in the JFTOT, both samples were tested using the Fuel Coker at 400/500°F test conditions. Both samples passed with a Visual Rating of Code 1 and 0.0 inch Hg pressure drop.

A series of additional JFTOT tests were conducted on the two samples by the AFAPL/SFF Fuels Branch. The results of these tests are given in Table 8 and are

TABLE 6

JFTOT TEST RESULTS FOR JPTS FUEL SAMPLES

Sample Nr.	Location	JFTOT Results Visual Code	Delta SPUN TDR	Delta P (mm Hg)
76-F-2501	Wallops	<2	4	0.0
76-F-2524	Wallops	1	5	0.0
76-F-2525	Wallops	1	4	0.0
76-F-2526	Wallops	1	4	0.0
76-F-2571	Ames	1	4	0.0
76-F-2572	Eielson AFB	3A	39	0.0
76-F-2573	Eielson AFB	1	5.5	0.0
77-F-61	Wallops	1	4	0.0
77-F-62	Wallops	1	3	0.0
77-F-63	Wallops	<2	4	0.0
77-F-74	Beale	1	3.5	0.0
77-F-145	Wallops	1	2.5	0.0
77-F-174	Wallops	1	2	0.0
77-F-175	Wallops	1	4	0.0
77-F-181	Moffett	1	3	0.0
77-F-221	Exxon	1	1.5	0.0
77-F-254	Eielson AFB	1	1	0.0
77-F-288	Wallops	1	2	0.0
77-F-289	Wallops	1	2	0.0
77-F-290	Wallops	1	3	0.0
77-F-425	Paul Marcus	1	3	0.0
77-F-457	Ames	1	3	0.0
77-F-594	Ames	1	3	0.0
77-F-615	Wallops	1	3.5	0.0
77-F-616	Wallops	1	3.5	0.0
77-F-617	Wallops	1	3.5	0.0
77-F-618	Chem-Trix	1	2.5	0.0
77-F-768	Wallops	1	9.5	0.0
77-F-767	Wallops	1	5.5	0.0
77-F-769	Wallops	1	9.5	0.0
77-F-806	Exxon	1	4	0.0
77-F-812	Ames	1	5	0.0
77-F-813	Eielson	4	48	0.0
77-F-814	Eielson	1	4.5	0.0
77-F-815	Eielson	1	3	0.0
77-F-816	Eielson	1	3.5	0.0
77-F-905	Wallops	1	9	0.0
77-F-906	Wallops	1	5.5	0.0
77-F-907	Wallops	1	5.5	0.0
77-F-1031	Ames	1	4	0.0
77-F-1077		1	5	0.0
77-F-1082	Wallops	1	6	0.0
77-F-1083	Wallops	<2	7	0.0

TABLE 6 (CONTINUED)

Sample Nr.	Location	JFTOT Results Visual Code	Delta SPUN TDR	Delta P (mm Hg)
77-F-1084	Wallops	1	2.5	0.0
77-F-1150	Paul Marcus	1	6.5	0.0
77-F-1153	Ames	1	4	0.0
77-F-1382	Ames	1	5	0.0
77-F-1568	Ames	1	6	0.0
77-F-1897	Wallops	1	6	0.0
77-F-1898	Wallops	1	5	0.0
77-F-1899	Wallops	1	5	0.0
77-F-1905	Exxon	1	5	0.0
77-F-1906	Ames	1	3.5	0.0
77-F-2004	Wallops	1	5	0.0
77-F-2005	Wallops	1	6	0.0
77-F-2006	Wallops	2	4.5	0.0
77-F-2013	NASA Houston	1	0	0.0
77-F-2127	Ames	1	3	0.0
77-F-2220	HiPort Ind.	1	4	0.0
77-F-2238	Wallops	1	4	0.0
77-F-2239	Wallops	1	4	0.0
77-F-2240	Wallops	1	3	0.0
77-F-2408	Wallops	1	8.5	0.0
77-F-2409	Wallops	1	3	0.0
77-F-2410	Wallops	1	3.5	0.0
78-F-7	Ames	1	5	0.0
78-F-148	Ames	1	5.5	0.0
78-F-159	Exxon	1	4.5	0.0
78-F-166	Wallops	1	3	0.0
78-F-167	Wallops	1	2.5	0.0
78-F-168	Wallops	1	2	0.0
78-F-204	HiPort Ind.	1	3	0.0
78-F-205	Pease AFB	1	2	0.0
78-F-206	HiPort Ind.	1	3	0.0
78-F-420	Wallops	1	6	0.0
78-F-518	Moffett	1	3.5	0.0
78-F-543	Wallops	1	5	0.0
78-F-544	Wallops	1	4	0.0
78-F-809	Wallops	1	6	0.0
78-F-810	Wallops	1	2.5	0.0
78-F-832	HiPort Ind.	1	2	0.0
78-F-946	Pease AFB	1	2	0.0
78-F-1067	Eielson AFB	1	3.5	0.0
78-F-1068	Eielson AFB	4	50	0.0
78-F-1079	HiPort Ind.	<2	5	0.0
78-F-1108	Beale	1	1	0.0
78-F-1109	Beale	1	4	0.0
78-F-1111	Wallops	1	6	0.0

TABLE 6 (CONTINUED)

Sample Nr.	Location	JFTOT Results Visual Code	Delta SPUN TDR	Delta P (mm Hg)
78-F-1112	Wallops	1	5.5	0.0
78-F-1113	Ames	1	4	0.0
78-F-1163	Exxon	1	4.5	0.0
78-F-1224	Ellsworth AFB	1	-	0.0
78-F-1260	Pease AFB	1	4	0.0
78-F-1297	Eielson AFB	4	4.8	0.0
78-F-1333	Beale AFB	1	3.5	0.0
78-F-1353	Wallops	1	5.1	0.0
78-F-1354	Wallops	1	5.2	0.0
78-F-1413	HiPort Ind.	2	9.8	0.0
78-F-1567	Moffett	1	5.5	0.0
78-F-1596	Wallops	<2	4.8	0.0
78-F-1597	Wallops	<2	5	0.0
78-F-1664	Moffett	1	5.8	0.0
78-F-1785	Wallops	1	7.3	0.0
78-F-1786	Wallops	1	4.3	0.0
78-F-1858	HiPort Ind.	1	6.2	0.0
78-F-1888	Moffett	1	5.6	0.0
78-F-1921	Pease AFB	1	4.2	0.0
78-F-1922	Pease AFB	1	5.0	0.0
78-F-1930	Ellsworth	1	6.4	0.0
78-F-1931	Exxon	1	8.8	0.0
78-F-2020	Ellsworth	1	3.9	0.0
78-F-2055	Wallops	1	6.8	0.0
78-F-2056	Wallops	1	6.9	0.0
78-F-2057	Wallops	1	6.9	0.0
78-F-2160	Exxon	1	2.0	0.0
78-F-2161	Johnson	1	3.8	0.0
78-F-2178	Pease AFB	1	5.0	0.0
78-F-2255	Moffett	1	4.6	0.0
78-F-2339	Wallops	1	4.9	0.0
78-F-2340	Wallops	1	5.0	0.0
78-F-2341	Wallops	1	3.0	0.0
78-F-2433	Pease AFB	1	2.4	0.0
78-F-2457	Anchor Tank	1	-	0.0
78-F-2536	Wallops	<2	5.4	0.0
78-F-2537	Wallops	1	4.2	0.0
78-F-2538	Wallops	1	3.5	0.0
78-F-2571	HiPort Ind.	1	1.2	0.0
78-F-2622	Pease AFB	1	2.7	0.0
78-F-2645	Wallops	1	6.7	0.0
78-F-2646	Wallops	1	5.8	0.0
78-F-2647	Wallops	1	6.6	0.0

TABLE 7

FUEL DATA SUMMARY FOR JPTS BATCH 79

Test	Sample Nr. 76-F-2572	Sample Nr. 77-F-813	Batch 79 Data (1)
Saybolt Color, D 156	+30	+30	-
Distillation, D 86			
Initial BP, °F	345	346	343
10% Recovered, °F	358	358	359
20% Recovered, °F	360	360	-
50% Recovered, °F	365	365	366
90% Recovered, °F	379	380	381
Final Boiling Point, °F	436	432	410
Flash Point, D 56, °F	125	124	125
Gravity, API (60°F)	49.7	49.7	49.7
Freezing Point, °F	B-64	B-64	-80.5
Aniline-Gravity Product	7554	-	7435
Copper Strip Corrosion	1A	-	1A
Thermal Stability			
Fuel Coker (D 1660) (2)			
Visual Code	1	1	1
Dif. Pressure, in. Hg.	0.0	0.0	0.3
JFTOT (D 3241) (3)			
Visual Code	3A	4	-
Max. Dif. TDR	39	47	-
Dif. Pressure, mm Hg.	0.0	0.0	-
Existent Gum D 381, mg/100 ml	0.2	0.0	0.2
Particulates, mg/gal	0.4	0.4	-
Anti-icing Additive, vol %	0.12	0.11	0.144

NOTE: Fuel stored in Drums, Eielson AFB, Alaska. Both samples from Batch 79 produced 8 August 1974 by Exxon Corporation.

(1) From original data sheet submitted when fuel was produced.

(2) Fuel Coker test conditions were 400/500°F for samples 76-F-2572 and 77-F-813 and 450/550°F for Batch 79.

(3) JFTOT test temperature was 335°C.

plotted in Figures 10 and 11. As evident in Figures 10 and 11, the two samples gave similar results indicating that the two samples, even though taken at different times and possibly from different storage drums, were essentially identical. A breakpoint temperature based on Visual Ratings is estimated to be 328°C (622°F) if abnormal colored deposits (i.e., blue or blue-green color) are ignored. The test temperature must be lowered to about 290°C (554°F) to eliminate the abnormal deposits. Using the Alcor Mark 8A TDR, a breakpoint temperature of about 305°C (581°F) is estimated for a SPUN TDR pass/fail rating of 12 TDR units.

Of interest in Table 6 is the lack of any increase in pressure differential across the JFTOT test filter for the 131 quality control fuel samples of JPTS fuel. However, as can be seen in Table 8, fuel Sample Number 77-F-813 did give some measurable increase in pressure drop across the test filter at lower test temperatures. This may indicate that at JFTOT test temperatures much above 300°C, the formation of filter plugging deposits lessens.

Subsequently, a drum of the Batch 79 fuel was obtained and additional JFTOT and Fuel Coker tests were conducted by SFQLA. The results are tabulated in Table 9. These JFTOT data along with previous data obtained by SFQLA are plotted in Figures 12 and 13. The breakpoint temperatures based on Visual and TDR ratings are 320°C (607°F) and 305°C (580°F), respectively. These results are in excellent agreement with the results obtained by AFAPL/SFF for JPTS Samples 76-F-2572 and 77-F-813. The Fuel Coker data from Table 9, along with the data from previous tests, are plotted in Figure 14 and indicate a breakpoint temperature of 431°F.

In summary, all of the 131 JPTS fuel samples submitted to SFQLA for quality control testing during approximately 25 months of 1976 through 1978 passed the

TABLE 8

JFTOT DATA FOR JPTS FUEL SAMPLES 76-F-2572 AND 77-F-813

Sample Nr.	Test Nr.	Test Temp (°C)	Visual Rating	Delta SPUN TDR	Delta P (mm Hg)
2572	3005	330	<3A	31	0
2572	3009	325	<3A	30	0
2572	3011	340	<4A	41	0
2572	3019	335	<3A	37	0
813	3084	325	>4A	44	10
813	3086	285	1	2.5	12
813	3088	305	<4A	24	7
813	3090	295	1A	7.5	14
813	3097	300	<2A	8	0
813	3100	305	1	4	0
813	3103	310	<2A	5.5	8
813	3106	315	<2A	11.5	8
813	3109	325	<3A	13	5

NOTE: The Visual Rating of A (Abnormal) deposit colors were blue or blue-green in color.

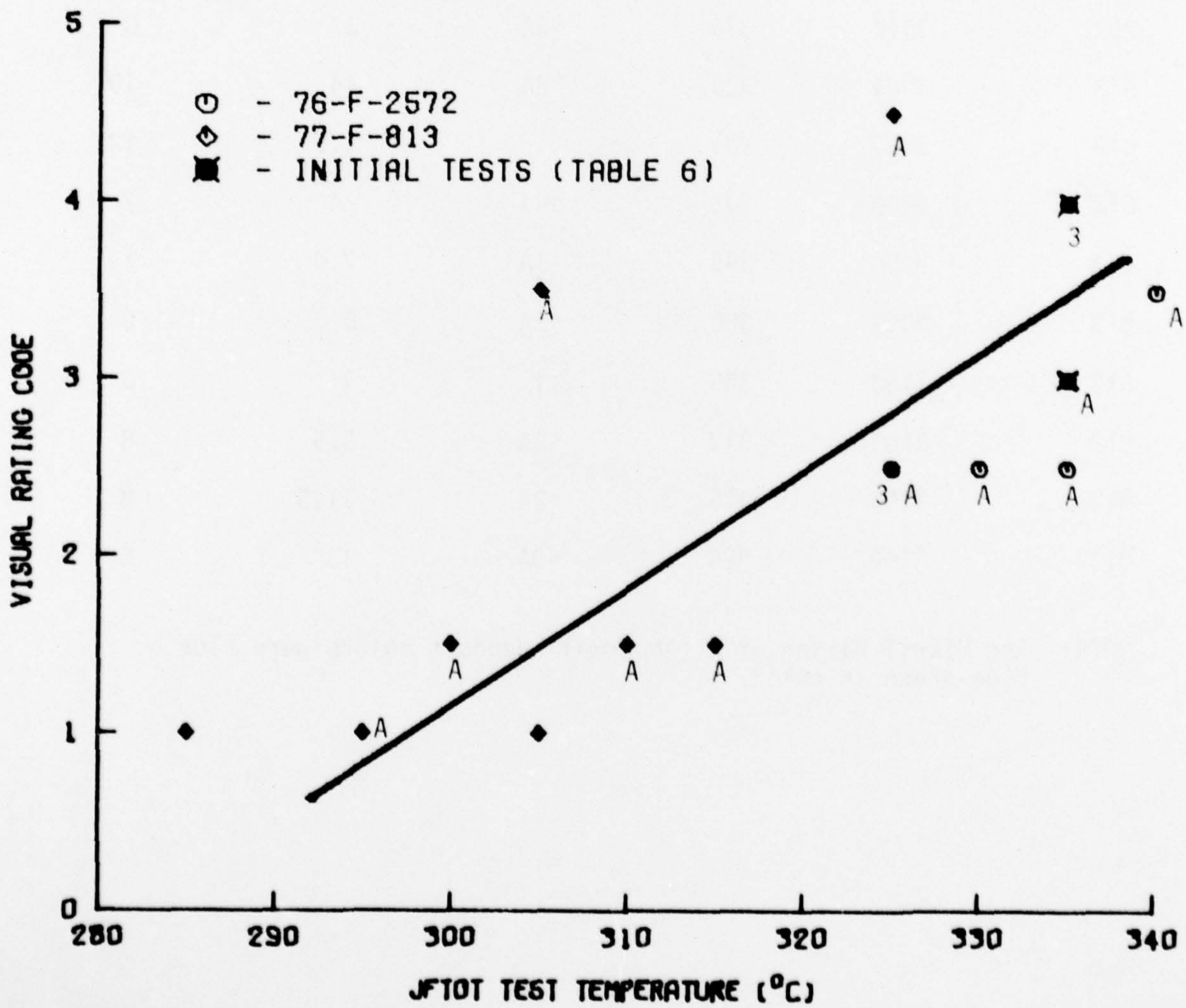

FIGURE 10. VISUAL RATINGS FOR FUEL SAMPLES 76-F-2572 AND 77-F-813

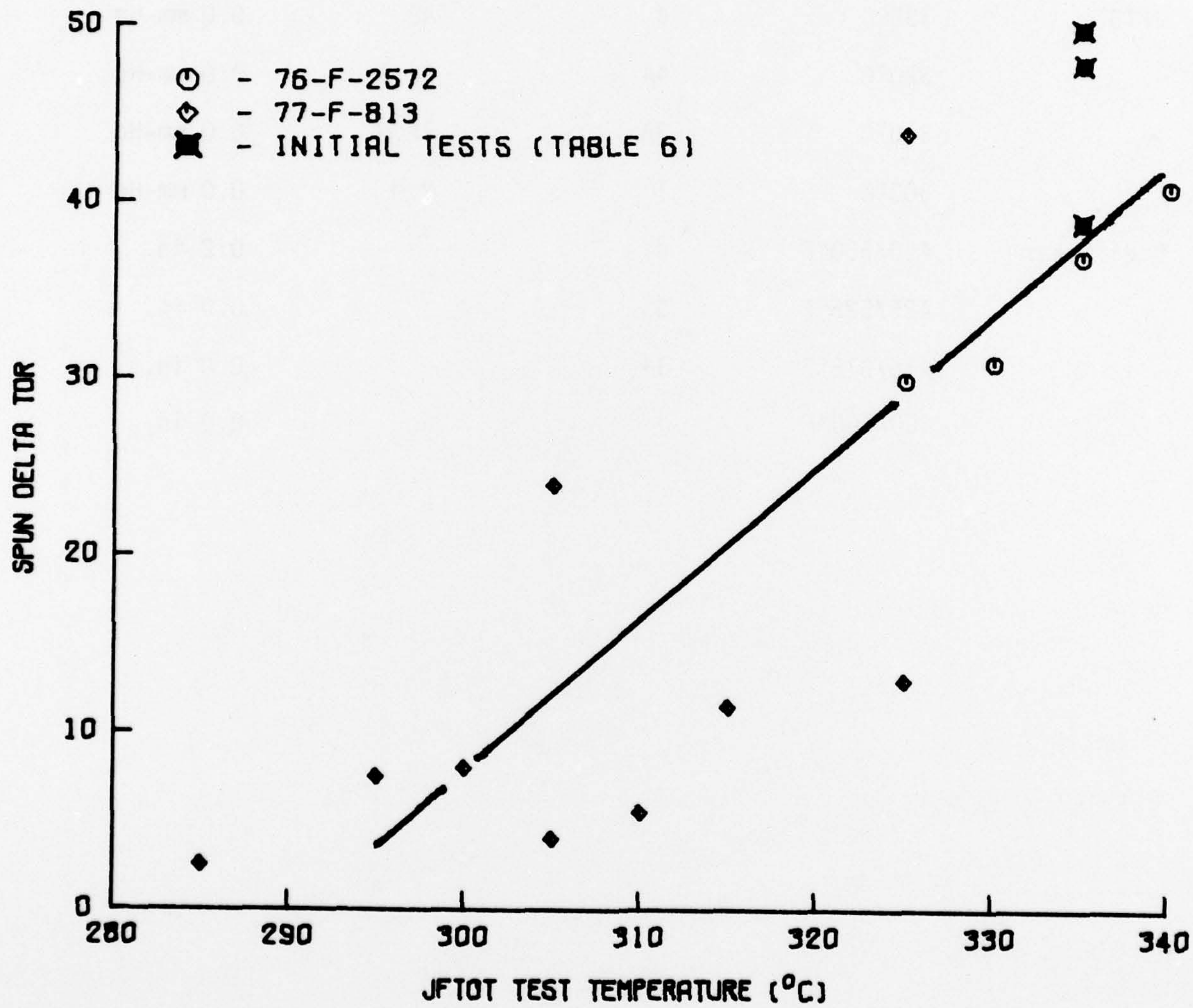

FIGURE 11. TDR RATINGS FOR FUEL SAMPLES 76-F-2572 AND 77-F-813

TABLE 9

JFTOT AND FUEL COKER DATA FOR JPTS BATCH 79

Test Device	Test Temperature	Visual Code	Delta SPUN TDR	Delta P
JFTOT	335°C	4	48	0.0 mm-Hg
	320°C	4A	32.1	0.0 mm-Hg
	310°C	3A	18.8	0.0 mm-Hg
	300°C	1	2.9	0.0 mm-Hg
Fuel Coker	450/550°F	4		0.2 in.
	425/525°F	3		0.0 in.
	415/515°F	1+		0.0 in.
	400/500°F	1		0.0 in.

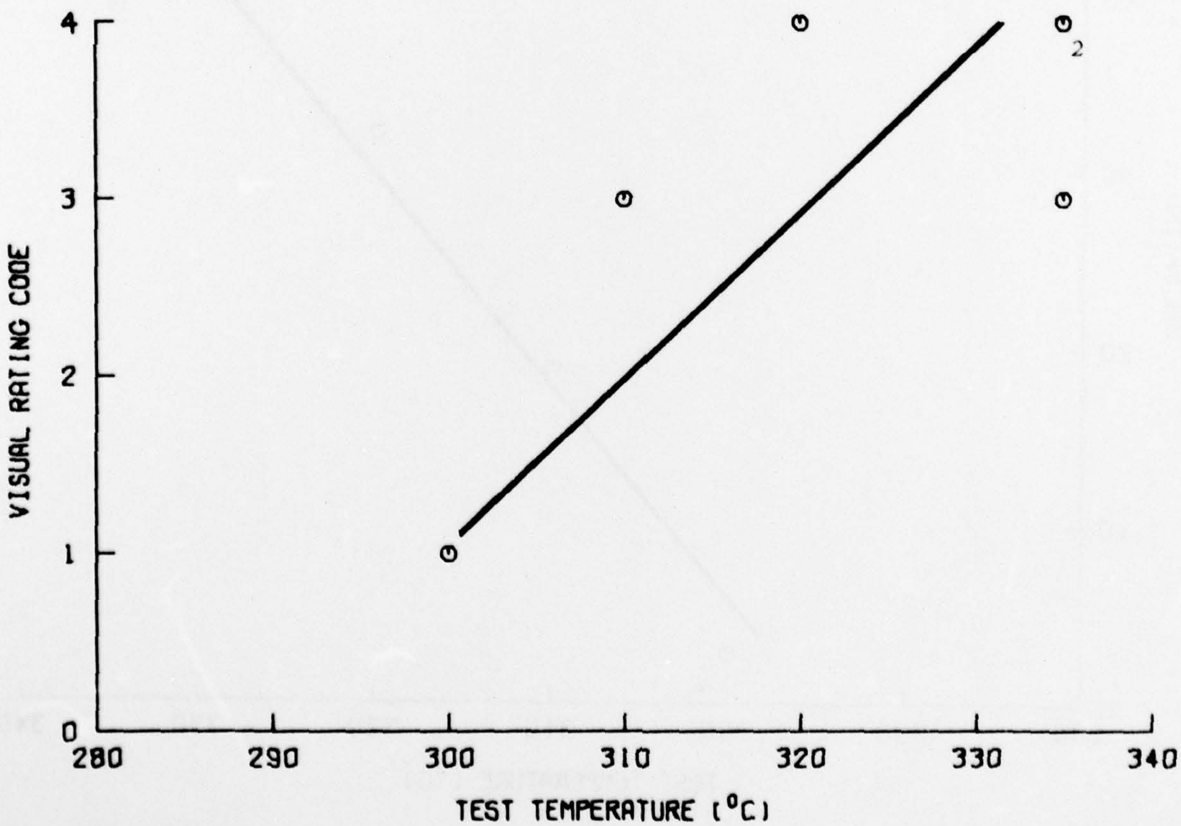

FIGURE 12. SFQLA JFTOT DATA FOR BATCH 79 - VISUAL RATINGS

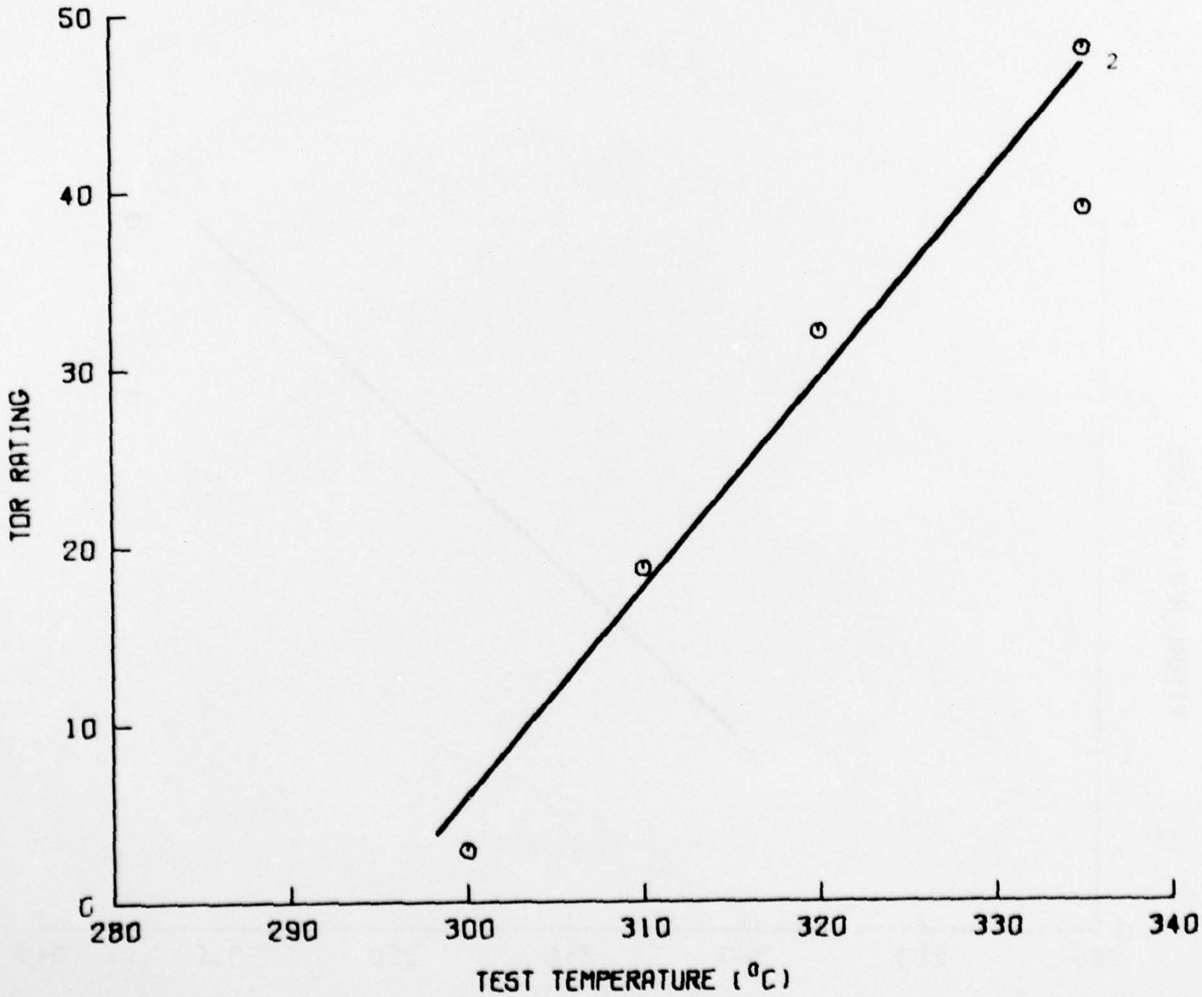

FIGURE 13. SFQLA JFTOT DATA FOR BATCH 79 - TDR RATINGS

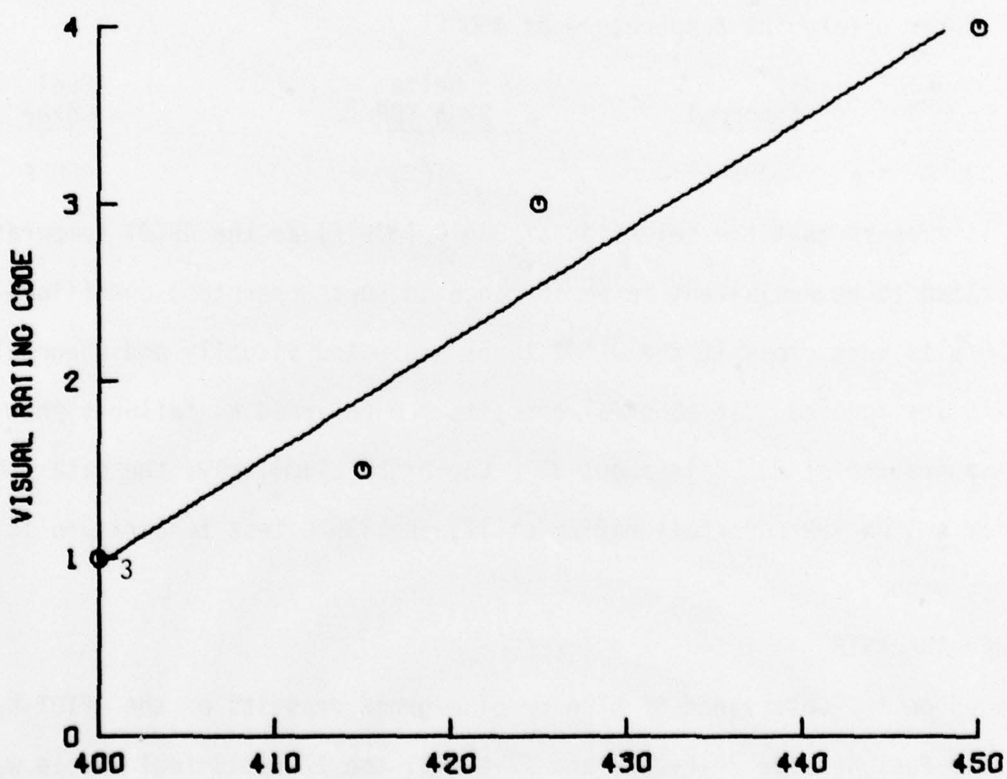

FIGURE 14. FUEL COKER DATA FOR BATCH 79

JFTOT test at a test temperature of 335°C with the exception of four samples, all from Batch 79 located at Eielson AFB. Extensive testing of the Eielson Batch 79 fuel indicates that the breakpoint temperatures as determined by the JFTOT and the Fuel Coker are:

JFTOT Visual		Delta	Fuel
≥ Code 3	Abnormal	SPUN TDR	Coker
328°C	290°C	305°C	431°F

Assuming a one-to-one breakpoint temperature relationship between the JFTOT and the Fuel Coker for the Batch 79 fuel, the following comparison results for a Fuel Coker breakpoint temperature of 450°F.

JFTOT Visual		Delta	Fuel
≥ Code 3	Abnormal	SPUN TDR	Coker
339°C	306°C	316°C	450°F

Thus, it appears that the selection of 335°C (635°F) as the JFTOT temperature anticipated to be equivalent in performance to Fuel Coker test conditions of 450/550/6 is very close if the JFTOT tubes are rated visually and abnormal deposits are ignored. If abnormal deposits are regarded as failures then the test temperature of 335°C is about 30°C too high. Similarly, the data indicates that for a SPUN TDR pass/fail rating of 12, the 335°C test temperature is about 20°C too high.

3. FUEL ANALYSIS

Based on the observance of blue or blue-green deposits on the JFTOT heater tubes for Fuel Samples 76-F-2572 and 77-F-813, the 77-F-813 fuel sample was subjected to trace metals analysis. Of particular concern was copper, as copper at concentrations as low as 50 ppb has been found to give blue and blue-green deposits along with reduced thermal stability.

Monsanto Research Corporation, under Air Force Contract, performed an analysis for copper using an acid extraction method followed by atomic absorption spectrophotometry. Only 4 ppb copper was found (Reference 11). Subsequently the same fuel sample was analyzed using emission spectrometry by Monsanto (Reference 12) with the following results:

Silicon	30 ppb
Magnesium	<100 ppb
Iron	<30 ppb
Aluminum	<30 ppb
Copper	Not Detected
Chromium	Not Detected
Nickel	Not Detected

These levels of trace metals appear to be much too low to account for the observed reduction in thermal stability or the abnormal deposits. The existent gum measurements for the two samples are also quite low (see Table 7) and do not explain the thermal stability reduction observed. In summary, the cause of the reduced thermal stability of fuel Samples 76-F-2572 and 77-F-813 is unknown.

SECTION VI

CONCLUSIONS

1. The JFTOT, using the Mark 8A Tube Deposit Rater, is a suitable replacement for the ASTM-CRC Fuel Coker for use in specifying the thermal oxidative stability of JPTS type fuels.

2. A JFTOT test temperature of 335°C (635°F) is estimated to be roughly equivalent in performance to the ASTM-CRC Fuel Coker at a test condition of 450/550°F.

3. JPTS may boil in the Fuel Coker at the specification test temperature of 450/550/6.

4. The higher operating pressure of the JFTOT (3.43 MPa) as compared to the Fuel Coker (1.03 MPa) is believed to significantly increase the test precision of the JFTOT.

5. The ALCOR Mark 8A TDR is significantly superior to the Visual Rating method for JPTS type fuels. The maximum SPUN TDR limit is best determined by subtracting the pretest tube rating from the post test rating to decrease the effects of tube variations.

SECTION VIII

RECOMMENDATIONS

It is recommended that military specification MIL-T-25524 be changed to permit the use of the JFTOT in lieu of the ASTM-CRC Fuel Coker for the thermal oxidative stability quality control determinations for JPTS fuels. A single JFTOT test temperature of 335°C (635°F) is recommended. The JFTOT heater tube deposits should be rated using the Alcor Mark 8A Tube Deposit Rater with a Delta SPUN TDR rating of 12 as the pass/fail limit.

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